

Frontrunners: a series of policy briefs to inform national governments
on the economic and social benefits of action for sustainable cities

Sustainable urban infrastructure for all: Lessons on solar-powered street lights from Kampala and Jinja, Uganda

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Summary

Providing access to affordable, reliable, sustainable and modern energy for all is the seventh Sustainable Development Goal. The New Urban Agenda also commits to the provision of inclusive and safe streets that are free from crime and violence, including gender-based violence. Solar-powered street lights can contribute to these goals by increasing the electricity supply, improving safety in urban areas and protecting the environment.

This paper offers lessons from the cities of Kampala and Jinja in Uganda, where solar street lighting has proven cheaper to build and operate than conventional street lights. It has also generated a range of economic and social benefits, including lower crime rates, better road safety, a more vibrant night-time economy and higher property values. Tens of thousands of working hours a day – equivalent to 14,000 full-time jobs nationwide – could be added to the economy by extending trading beyond daylight hours. Based on this case study, installing and maintaining solar-powered LED street lights across sub-Saharan Africa rather than conventional grid-based options could reduce upfront installation costs by at least 25 percent, electricity consumption from street lighting by 40 percent and maintenance costs of new roads by up to 60 percent. Lighting new roads in sub-Saharan Africa with solar would be an opportunity to generate between 96 and 160 GW of distributed renewable energy across the sub-continent, more than doubling sub-Saharan Africa's current energy generation capacity of 92 GW.



Photo credit: Visty Banaji

About this policy brief

This policy brief was prepared by the University of Leeds. It was developed in partnership with the Coalition for Urban Transitions, which is a major international initiative to support decision makers to meet the objective of unlocking the power of cities for enhanced national economic, social, and environmental performance, including reducing the risk of climate change. The research presented here was conducted in support of the Coalition's Economics workstream, and builds on previous University of Leeds and Coalition research on the economic and social benefits of low-carbon cities. The opinions expressed and arguments employed are those of the authors.

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In order to realise these benefits, national governments should create a more robust regulatory framework to grow and manage domestic solar markets. Ensuring a wide range of stakeholders – including local communities – are involved in planning and implementing such projects will help to maximise social impact and economic returns. It will also enable knowledge spillovers that allow solar lighting and other emerging low-carbon technologies to quickly achieve scale. These targeted efforts should be underpinned by capacity building for municipal governments, who need to strengthen their project delivery and budgeting capabilities in order to deliver sustainable urban infrastructure at scale.

This policy brief is one of a series on frontrunning climate actions in cities around the world. The objective of this series is to strengthen the evidence on the economic and social implications of low-carbon, climate-resilient urban development. The series focuses on providing robust data on actual or ex post outcomes of climate action, ranging from better public health to job creation to greater equity. Each case study explores some of the preconditions for the successful design and delivery of urban climate action and provides national policy recommendations that could enhance their effectiveness and benefits.

Highlights

- In developing countries, entrenched poverty and rapid urbanisation are putting pressure on municipal authorities to improve basic public service provision for urban populations, especially in informal settlements.
- One area of public service provision where there is a clear need, and potential, for improvement is street lighting. Street lighting plays a crucial role in public safety, especially for women, and the promotion of inclusive social and economic development. Efficient and more sustainable lighting technologies, such as LED lights powered by solar energy, are emerging and could bring many benefits.
- At present, basic public services such as street lighting are lacking in many African cities. In Uganda, the ambitious development plans of the cities of Kampala and Jinja have been constrained by inadequate municipal finance that has resulted in street lights being turned off, with subsequent negative social and economic impacts.
- In Kampala and Jinja, solar-powered street lighting has proven cheaper to build and operate than conventional street lights. It has also generated a range of social and economic benefits such as inclusion of marginalised groups, reduced crime rates, improved road safety and an enhanced night-time economy. Tens of thousands of additional working hours a day could be generated by strengthening the night-time economy. This could equate to approximately 4,000 more full time jobs in Kampala and approximately 14,000 more nationwide.
- According to the National Roads Authority, there are 2,800 km of urban roads in Uganda. If these were fitted with conventional street lighting, the initial cost would be 896 billion UGX (~238 million USD), further increasing the already unaffordable cost of electricity for the authorities. If they were fitted with solar street light poles, then the initial cost would be 672 billion UGX (~178 million USD) with no added electricity costs for the authorities. If the solar poles were partly fabricated locally, the cost would drop to 448 billion UGX (~119 million USD).
- Across sub-Saharan Africa, installing and maintaining solar-powered LED street lights as opposed to conventional grid-based lighting could reduce upfront installation costs by at least 25 percent, electricity consumption by 40 percent and the maintenance costs of lighting by up to 60 percent. Lighting these new roads with solar power would be an opportunity to substitute consumption of grid-based electricity with the generation and consumption of between 96 and 160 GW of distributed renewable energy, equivalent to more than doubling energy generation in sub-Saharan Africa, currently at just 92 GW.¹
- Solar-powered street lighting has particular benefits for informal settlements. In Kibugumbata, Jinja, the co-production of solar-powered street lights has created jobs in the solar sector for a vulnerable population

while helping to strengthen existing livelihoods by allowing trading to continue outside of daylight hours and enhancing safety and security in the area. Such multi-stakeholder models – which include local residents, non-governmental organisations (NGOs), and local and national government – can transform the relationship between the urban poor and the state, contributing to more sustainable and inclusive urban development.

- A number of challenges to rolling out solar street lights at scale exist. Lack of technical capacity hampers the tendering process and means municipalities rely on external donor expertise for developing city plans. Although the economic case for choosing solar over conventional street lights is clear, there is still a lack of capital in the short-term and a high risk that replacement lights could be unaffordable if municipal budgeting is not improved.
- To overcome these challenges, national governments should create an enabling environment for investment in sustainable urban infrastructure such as solar-powered street lights by: creating a more robust regulatory framework to grow and control domestic solar markets; building the capacity of municipal staff to plan, finance and deliver infrastructure projects; and ensuring a wide range of stakeholders – including local communities – are involved in the planning of projects in order to maximise the social returns.

Meeting the growing demand for sustainable urban public services

THE GLOBAL CHALLENGE

Population growth, economic development, infrastructure expansion and land use change are all key factors resulting from the rapid growth of cities worldwide. 68 percent of the global population is projected to be living in cities by 2050, with the vast majority of this growth in urban populations taking place in Asia and Africa.² There are a number of specific urban development challenges that are characteristic of the African context, including increasing poverty and rising inequality within cities, and deficits in infrastructure provision and investment at the municipal level.³ These are even more pronounced in smaller and intermediate size urban centres, where poverty is often entrenched and local authorities' capacity to provide risk-reducing infrastructure is low.⁴

The lack of sufficient urban infrastructure means failing to meet the growing demand for basic public services, and can put considerable strain on local finances, capacities and environments.⁵ This is particularly problematic in sub-Saharan Africa, where annual municipal budgets can be as low as 0.02 USD per capita (as in Abidjan, Cote d'Ivoire).⁶ The World Bank's Global Infrastructure Outlook dataset shows a growing 'investment gap', more than half of which is due to a considerable shortfall in investment in the roads and electricity sectors in developing economies (8.9 trillion USD and 2.9 trillion USD respectively).⁷ In order to fill this gap, national policymakers and other key stakeholders need to mobilise and deploy finances in the most effective, efficient and equitable ways possible.⁸

Opportunities for public investment or for securing private sector and donor financing are often prioritised towards 'central business districts' and other parts of the city that are seen to be the engines of formal economic growth and where tax returns might repay investments.⁹ This can marginalise informal sectors of the economy and informal settlements. Municipal authorities may seek to justify this on 'rational' economic grounds, stating that investment in services and infrastructure goes towards the parts of the city that generate revenues. However, this risks exacerbating already unsustainable levels of social, economic and political inequality.

Informal settlements and low-income neighbourhoods tend to have higher crime rates, insufficient or insecure employment opportunities, and are often disconnected from the rest of the city (e.g. in spatial, transport and electricity terms), creating an uneven 'infrastructure landscape'.¹⁰ 60 percent of urban dwellers in developing countries have been victims of crime, typically burglary and assault¹¹ and those working in the informal economy, particularly

street vendors in Sub-Saharan Africa, do so in unregulated and unprotected environments that threaten their safety and impose limits on their livelihoods.¹²

THE MULTIPLE BENEFITS OF CITY LIGHTING

The socioeconomic case for expanding the provision of public services to all parts of the city is clear. Relatively small improvements in transport networks and basic public services such as street lighting can lead to big gains in terms of reducing accidents and crime rates, alongside increasing economic activity on the streets.

Africa has the highest rate of fatalities from road traffic injuries in the world.¹³ Visibility is a key factor in reducing risk, especially for pedestrians – in most urban centres in Africa, walking is the primary mode of transport. Inadequate public services have been linked to rising crime rates in some African cities.¹⁴ Investing in street lighting can improve safety and security, especially for women. Indeed, investments in this area could be part of the gender responsive approach to urban planning that has been called for in the global south and African countries.^{15,16} Street vendors are a significant contributor to livelihoods and urban economies but poor lighting can limit trading to daylight hours only.¹⁷

The potential co-benefits for social cohesion and community empowerment are also considerable. If communities are directly involved in the provisioning and safeguarding of services then this can act as a catalyst for ongoing formal engagement with municipal authorities, creating scope for joint-financing and even improving revenue collection by increasing compliance from tax payers who feel part of a city.¹⁸

SOLAR ALTERNATIVES TO CONVENTIONAL STREET LIGHTS

Favourable economics and a renewable, low carbon power source make solar lights more attractive than ones reliant on centralised grids and fossil fuels. Conventional grid-based lights and solar street lights are comparable inasmuch as they look the same, are roughly the same height (around 3 metres) and provide the same basic amenity – light. Although there may be differences in the brightness and ‘visual warmth’ that the solar street lights provide, the socioeconomic benefits of illumination, outlined above, remain the same.

Conventional street lights require grid-connectivity and sufficient roadside space for cables to connect them to nearby power distribution sources. In unplanned and developing urban areas this can be problematic because of poorly managed streets and a lack of existing infrastructure. Here, the benefits of using standalone solar lights become clear. Utilising solar photovoltaic panels and batteries, the street light poles can be installed anywhere there is sufficient sunshine to power them. During daylight hours, the panels convert solar radiation into energy that is stored in the batteries, ready to power the lights at night. Panels and batteries can be installed on each individual pole, or at a mini power station that fuels a group of lights.

Solar-powered street lights can provide citizens with a constant source of light even during the frequent power outages that are common in developing countries. The upfront capital required, as well as the operation and planned maintenance costs, are often lower for solar-powered lights (though unplanned maintenance requirements – such as the repair of faulty lamps – can be costly).¹⁹ Money saved on electricity bills can be reinvested elsewhere. For example, it could be put towards installation costs, enabling municipal authorities to bring the multiple benefits of well-lit streets to larger numbers of city dwellers.

Successful adoption of solar alternatives to conventional street lights depends on more than just the availability of new technology. Local technical capacity, favourable cultural norms, appropriate physical geography, relevant knowledge and skills, and supportive institutions are all needed to create a sufficient level of ‘absorptive capacity’. For instance, cities wanting to roll out decentralised and renewable energy technologies to meet urban service demands cleanly and cheaply will need strong local markets and private sector buy-in as well as competent contractors and flexible urban planning strategies to make this a viable and attractive alternative to following the usual high-carbon pathway of grid expansion.

Methodology

Two cities in Uganda, the capital Kampala and a key ‘secondary city’, Jinja, were selected as case studies. National policy documents and city development strategies were analysed. Based on this analysis, and consultations with research colleagues at Makerere University in Kampala, a range of stakeholders were identified, and 23 detailed semi-structured interviews were conducted: 8 with national and city level officials, 5 with non-government organisations at the national and local levels and 10 with randomly selected members of the local communities where solar lighting had been installed including business owners, pedestrians and road users. Site visits were also made to various streets in both cities to observe the levels of activity at different times of day.

Table 1
Breakdown of interviewee profiles

Stakeholders	Method
National government	2 interviews
City government	6 interviews
Civil society organisations: national and local level	5 interviews
Local beneficiaries: businesses, pedestrians and households	Site walks and 10 interviews

The policy context: Decentralised energy and urban development in Uganda

With a population growth rate of 3 percent and a rural-to-urban migration rate of 5 percent, the number of Ugandans living in cities could reach 30 million by 2040.²⁰ 70 percent of Uganda’s non-agricultural gross domestic product is generated in urban areas.²¹ The need for reliable and efficient energy services to these centres is clear.

Alongside opportunities for economic growth, urbanisation in Uganda also places significant strain on public finances and services. While national urban policies and infrastructure strategies are in place in many sub-Saharan African countries, financing and implementing such programmes will be a tremendous challenge: tackling the infrastructure deficit could cost up to 93 billion USD a year over the next 30 years, and would require well-coordinated multilevel governance structures to be in place.²²

Since the 1980s, Uganda has sought to encourage good governance at the local level through the decentralisation of finances and service delivery; underpinned by the constitutional commitment to ensure ‘each local government unit [has] a sound financial base with reliable sources of revenue’.²³ The democratic decentralisation process means that opposition parties control some cities: however, in practice, these municipal authorities may be subject to national government involvement in local politics and reduced funding.²⁴

Governance issues are compounded by the country’s weak tax base. Despite progress in the collection of own-source revenues in Kampala, authorities throughout Uganda are still struggling to collect taxes due to various barriers, including politicisation that restricts the use of certain taxes, and the predominance of the informal sector.²⁵ Municipal authorities remain heavily dependent on financial transfers from central government that can be unreliable or for lower amounts than is needed.

Uganda's national energy mix is heavily reliant on hydropower for its electricity (450 MW of 600 MW per annum).²⁶ This makes the carbon emissions of the sector low compared to other nations, and contributes to Uganda's Nationally Determined Contributions under the Paris Agreement.²⁷ Since grid electricity in Uganda is already relatively low-carbon, decentralised renewables and energy efficiency measures may not necessarily offer the same climate improvements as they might in, for example, southern African countries with more carbon-intensive grids. However, hydropower stations in Uganda, and East Africa as a whole, are concentrated in the Nile river basin and, as rainfall variability in this zone increases, energy generation becomes increasingly vulnerable to the impacts of climate change.

Uganda's Vision 2040 outlines its development aspirations for a range of sectors and the investments needed to achieve them.²⁸ Diversifying the energy mix is a stated aim, though investment to-date shows limited progress.²⁹ The country expects to be consuming almost 42 GW of electricity annually by 2040 due to rapid increases in demand as the population and the economy grow. This increase in demand will be met by increasing capacity from a number of different energy sources, including an estimated 5 GW of solar photovoltaic electricity.

The case study: Costs and benefits of rolling out solar-powered street lighting in Kampala and Jinja

KAMPALA

Kampala is the capital city of Uganda, with a population of 1.5 million within the city boundary³⁰ and 3.5 million in the greater metropolitan region.³¹ An expected 8 million people will be living in the metropolitan area by 2040.³²

There is a concerted effort by the Ugandan central government to ensure that the Greater Kampala Metropolitan Area – which includes three other districts home to many of the people who move in and out of the city on a daily basis – is developed in an integrated way. Much of this development strategy focuses on improving the road network to better connect different areas of the city and to reduce congestion within the central business district.

Kampala Capital City Authority (KCCA)'s strategic plan for 2014–2019 includes the intention to revamp the city's street lighting, noting that only 115km of the city's 1200km of roads have been fitted with lights, of which only 8 percent were functioning.³³ This is a serious problem as walking is the main mode of transport in the city, with 70 percent of residents walking to work.³⁴ In 2004/5, road traffic incidents accounted for 49 percent of injuries at the government hospital in Kampala, involving both passengers and pedestrians.³⁵ Given the scale of urbanisation since then, these numbers and their associated costs to life, healthcare and the economy are likely to now be even more significant.

KCCA has developed new strategic plans for urban development and addressing climate change,^{36,37} securing popular support and backing at the executive level for pursuing low-carbon and least-cost development pathways. At the city level, the political and economic context for addressing these challenges and implementing these plans is optimistic but financially constrained. In 2011, the city government was restructured and rebranded as Kampala Capital City Authority. Since then, the KCCA has achieved remarkable progress in generating own-source revenues, which now constitute around 30 percent of total revenue;³⁸ they have successfully sought to foster a 'culture of tax-paying' by introducing electronic payments and records for various sectors and revenue bases across the city.³⁹ However, the city is still plagued by a low per capita budget of around 29 USD per year.⁴⁰

The city's property rates – the tax through which the revenue for specific services such as street lighting is collected – generates relatively large sums annually. However, these funds are not separated from KCCA's main account, nor are they earmarked for the services they are meant to provide.⁴¹ Budgeting practices and structural challenges – such as energy costs and infrastructure lock-in – threaten to further undermine these financial gains. Transfers from central government can be unreliable or insufficient, and fall below predictions.⁴²

In part as a result of these fiscal constraints, KCCA has missed payments on its electricity bill, leading to considerable debt with their supplier and even prompting a plea for residents to consider paying for installing and maintaining their own street lighting.⁴³ With considerable road network expansion already underway, the French international technical cooperation agency (Expertise France) is supporting KCCA to develop a street lighting master plan and to find ways to reduce the city's electricity consumption.

JINJA

Jinja is the main city of Jinja District. The city itself has a population of 76,000, with up to 300,000 additional people coming into the city to work in the day.⁴⁴ Around 80 percent of households are not 'decent dwellings', according to the census, and there is a high level of unemployment as well as significant disparities in access to public services between different neighbourhoods.⁴⁵ The city's sustainable energy transition strategy includes the roll out of solar-powered street lighting.

Positioned at the source of the Nile, Jinja is home to considerable hydroelectric energy resources. However, as in Kampala, the Jinja Municipal Council (JMC) struggles with insufficient transfers from central government and inadequate revenue generation capacity, and like KCCA has run up a significant debt with its electricity provider. When the city's debt to the provider passed 1 billion UGX (~268,000 USD), the street lights were cut off. According to local government representatives, crime rates rose and economic activity was restricted to daylight hours, as both businesses and patrons avoided the streets because of security concerns. Despite public outcry, the city government has been unable to reinstate lighting. Instead, they have encouraged local homeowners to install their own security lighting.

Jinja has been part of a series of national level programmes designed to upgrade informal settlements and city infrastructure. The city received almost 2 billion UGX (~531,000 USD) from the World Bank's Uganda Support to Municipal Infrastructure Development Programme (USMID), which has been used to invest in upgrading the city's road network and street lighting. USMID funding for new lights is directed towards priority areas in the city centre, while low-income neighbourhoods on the urban periphery remain unserved.

Jinja is also part of the Government of Uganda's Transforming the Settlements of the Urban Poor in Uganda (TSUPU) programme. TSUPU established a Municipal Development Forum (MDF) in Jinja (as well as in other cities in Uganda) to bring together different stakeholders including the urban poor so as to align urban development issues at the national, municipal and community levels. With support from the National Slum Dwellers Federation of Uganda (NSDFU), the Jinja MDF carries out enumeration exercises in Jinja's informal settlements, feeding these into government initiatives to formalise settlements and better integrate them into urban planning and public service provision.

One settlement where the MDF and NSDFU have been active is in Kibugumbata. This 8-acre slum, home to 6,000 people, has literally been 'put on the map' of the city government's development plans. The availability of better data and formal recognition enables all levels of government to channel public investment into deprived areas in a more systematic and inclusive manner, such as through the co-production of plans and the co-financing of infrastructure.

SUCCESSSES: THE SOCIO-ECONOMIC CASE FOR SOLAR STREET LIGHT ROLL-OUT

In both cities, development plans and ongoing projects prioritise resurfacing old roads, building new ones, and upgrading and installing street lights – all of which could prove to be resource intensive, expensive and focused on relatively wealthy parts of the city. Alternatively, if these projects were to incorporate low-carbon options such as solar street lighting, and to include low-income neighbourhoods such as informal settlements, they could contribute to both climate and human development goals.

Municipal decision makers in both Kampala and Jinja indicate a preference for installing solar street lights over conventional ones. This is driven by a perception of more favourable economics over the long term; avoiding the significant electricity bills and debt servicing that have been a drain on municipal finances is a top priority. Switching to solar-powered street lighting is seen as one way to do this, while also bringing about other social, economic and environmental benefits. In both cities, the roll out is in early stages and is being evaluated closely to determine the viability of expanding projects and attracting investment.

So far, KCCA has installed around 1,800 solar street lights in Kampala, with around 750 of these in the central business district. The majority of the lights are being installed on new and renovated roads, with only a few being used to upgrade or replace damaged existing conventional lights. In Jinja, 92 solar street lights have been installed by the municipal council: 70 along a 2.5 km stretch of the main road through the town that is being built by USMID, and 22 on priority streets outside the hospital and market areas. A further 20 have been installed by the NSDFU with support from an NGO – ACTogether – in the informal settlement of Kibugumbata. Several have also been installed by a private sector bank on the streets surrounding its premises.

On new roads, or where no street lights have been previously installed, the upfront capital cost of a solar street light is generally cheaper than for a conventional one. The exact costs and savings vary depending not only on the technology used (e.g. which type of lighting or battery) but also on the physical planning particularities of where they are being installed. For instance, in poorer parts of the city where new cables and transformers would need to be installed to supply conventional lights, solar is considerably cheaper.

Across the two cities, the average cost has been around 6 million UGX (~1,600 USD) per solar street light pole, compared to 8 million UGX (~2,150 USD) for a conventional street light pole. So far, the total capital costs of KCCA's three solar lighting projects is 13.2 billion UGX (~3.5 million USD) – this is roughly equivalent to savings of almost 4 billion UGX (1 million USD) compared to conventional lighting. In Jinja, the municipal council has invested 170 million UGX (~45,500 USD), saving around 55 million UGX (15,000 USD) compared to conventional street lights.

The difference in operating costs is where the economics of solar-powered, compared to conventional, street lighting become most compelling. In the case of solar, there are almost zero operating costs, whereas the cost of power supply for conventional lights adds to already unsustainable utility bills. On average, KCCA currently spends in the region of 130 million UGX (~35,000 USD) on monthly electricity bills. This is equivalent to only 1/3 of the actual bill, which means they are accruing significant arrears each month, already totalling almost 1 billion UGX (~270,000 USD); the same situation in Jinja led to a total debt of 1.2 billion UGX (~350,000 USD) and the lights eventually being switched off. JMC is now servicing that debt to the utility company through tax waivers.

Maintenance costs are also an important consideration as the costs of repairing damaged lights and replacing faulty or worn out technology differs remarkably. Although most new solar lights have an estimated lifespan of up to 15 years, poor maintenance can mean they need replacing within 10. Typically, this will be for around 95 percent of the original cost. Planned maintenance itself is low cost, amounting to regular cleaning of panels during summer months and routine checks and servicing of electrical components. Arguably, conventional poles require more specialist and costly maintenance due to their grid connectivity, although this may be partly covered by utility companies.

The immediate benefits of solar-powered street lights are clear. City governments can drastically reduce their monthly expenditure on electricity bills and road users and pedestrians have more reliably, or newly, lit streets. The knock-on effects of this are numerous (see Figure 1). City governments can redirect saved funds into installing more lighting, maintaining existing ones or into other public services. In addition, both city governments have raised revenue by selling advertising space on the poles. It can also help to reduce city government reliance on transfers from national government – freeing up fiscal space at the national level for other investments.

Box 1

Economic advantages of solar street lights in Kampala

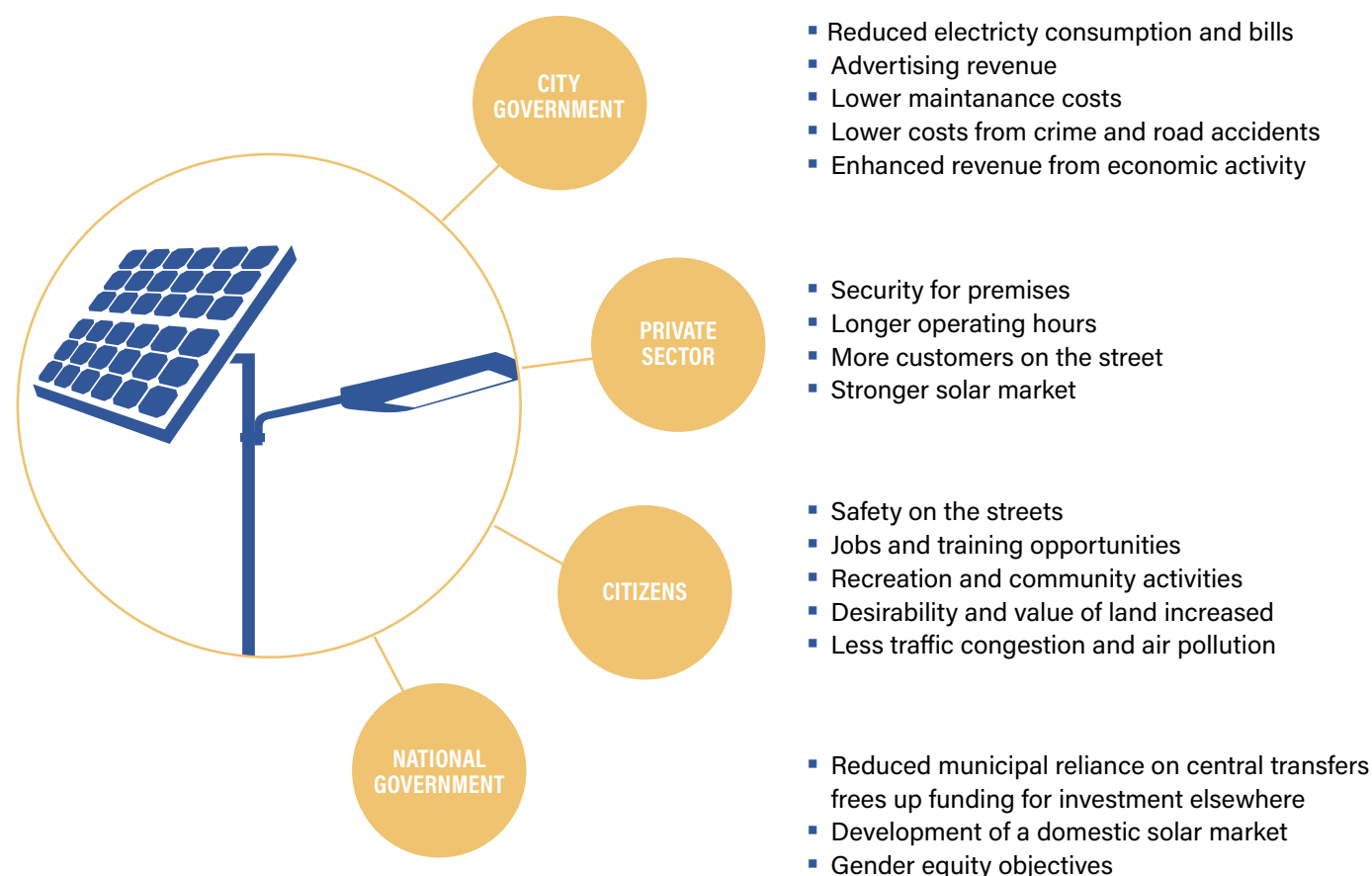
- 1,800 solar street lights have been installed to-date.
- In total, these solar lights were 3.6 billion UGX (~950,000 USD) cheaper than conventional street lights.
- The current electricity bill for street lighting is 130 million UGX (~35,000 USD) per month. This could be cut entirely if the city switched to solar street lights.
- It would be at least 80 billion UGX (~21 million USD) cheaper than conventional lights to install solar poles throughout Kampala.
- 1.6MW of capacity of renewable energy would be added to the city's profile.
- 42,500 working hours per day could be added to the city's economy by empowering street vendors, equivalent to adding almost 4,000 more full time jobs in the city.

Solar-powered street lighting also presents an opportunity to develop a domestic solar market by training solar technicians and manufacturing the street lights locally. Both Kampala and Jinja have nascent solar markets that trade components and community-based organisations that provide skills training to local people. This was especially apparent in Jinja, where, due to the involvement of NSDFU and their links with SDI (Shack/Slum Dwellers International), local businesses were contracted to produce the poles. Young people from the informal settlements were provided with training to do this, which has enabled them to continue to gain work in the sector and to pass on their skills to others in the community through workshops. This could contribute to job creation at a national scale.

Improved street safety can support a wide range of social and economic activity which can enhance prosperity nationwide. When lighting is installed on busy roads and junctions, accidents are reduced and traffic is eased, which helps address congestion and air pollution. Better lighting enables street traders to work for longer and during the busiest part of the day for trading (early evening). Interviewees reported a reduction in actual and perceived crime rates, thereby making an area more appealing and helping make pedestrians feel safe. This is especially important for women, whose safety and wellbeing have been directly linked to the level of lighting on city streets.^{46, 47} Female street vendors in particular benefit because they depend on the use of otherwise unsafe public spaces for their livelihoods.⁴⁸ Achieving gender equality in this area can help to boost national economic growth and lead to better development outcomes.⁴⁹

Better lighting also improves access and perceptions in affected areas, increasing the value of properties. It enables recreation and community activities by providing safe, accessible and usable public spaces and access routes for pedestrians. Again, these benefits are particularly important for empowering women and enabling them to reap the social and economic benefits of urban life.⁵⁰ So far, in both cities, development has focused on central areas of economic activity – where city governments can extract the most revenue – but, if solar lighting was rolled out to poorer parts of the city, these wider non-economic co-benefits would be considerably greater.

Figure 1

Co-benefits of solar street lighting for different stakeholders**Maximising co-benefits: Installing lights in Kibugumbata informal settlement in Jinja**

After the street lighting was switched off in Jinja in 2017, crime rates in and around Kibugumbata increased rapidly. Locals reported that significant numbers of violent and sexual crimes and robbery were occurring, meaning the streets became deserted after dark, with no pedestrians or traders. Women were most often the victims of these crimes, and those working in the informal sector – such as street vendors – were unable to work safely. Finding a way to return lighting to the streets was identified as a top priority by the local MDF. In 2017, the MDF and NSDFU secured funding from SDI to install 20 solar street lights.

Despite pressure from the city government to site the poles at a more central location, a memorandum of understanding was signed to secure a financial contribution from JMC and to grant development permission for the road reserves (the land adjacent to the roads used for signage and drainage etc.). Five youths from Kibugumbata were trained to become solar technicians and took control of the technical aspects of the project. The poles were manufactured locally, and the rest of the technology was bought from a firm in South Africa, costing an average of 4 million UGX (~1,000 USD) per light. The 60-watt LED lights illuminate two of the main streets in the informal settlement where businesses operate.

Since the lights were installed in March 2018, the benefits to the local community have been evident. According to local residents, there have been no recorded instances of serious crime and residents feel safer. Business owners are able to trade for an additional five hours per day and have many more customers due to the streets being busy again, with the extra trading reported to be equivalent to around an extra \$20 per day. The five solar technicians have continued to receive work maintaining the lights in the informal settlement (for which they receive payment from the JMC) and elsewhere in the city (for paying customers), and they have also branched out into domestic solar systems. This spill-over effect of the solar transition was visible in the settlement, where households with photovoltaic panels and batteries at home had access to, and were selling, energy services such as phone charging. The pole manufacturers are awaiting an order from JMC and SDI for their next projects.

CHALLENGES: MUNICIPAL BUDGET CONSTRAINTS AND OUT-DATED TECHNOLOGY

Despite the clear economic case and numerous co-benefits for investing in solar-powered street lighting, a number of challenges to their widespread uptake remain. At the investment stage, there is a risk that the technology purchased may be outdated and inefficient because the sector is developing so quickly. There is also a lack of expertise around contracting and procurement. In Kampala, initial phases of contracting proved expensive compared to subsequent ones as the technology improved and commissioners became better acquainted with the market. This is a particular risk in sub-Saharan African where, without proper regulations and standards in place, ‘technology dumping’ may lead to old and inefficient equipment being installed by manufacturers who cannot find a market for their products in other countries where these rules are in place.⁵¹

The cost of replacing damaged or faulty solar street lights may prove problematic in some cities, as replacing conventional lights with solar ones does not simply remove the need to budget for maintenance costs. Both KCCA and JMC were not factoring this into their annual budgets, risking finding themselves in the same situation of having built infrastructure that they cannot afford to service or use in the long-term. Traffic collisions, vandalism and theft involving solar-powered street lights were all reportedly common in both Kampala and Jinja, and solar technology can be costly to replace – at up to 95 percent of the original cost. The same budgeting issues that affect municipalities’ ability to pay electricity bills could mean proper maintenance is neglected. This ‘operation and maintenance’ paradox, whereby new infrastructure is needed and is being built while existing assets fall into disrepair, is a significant challenge in developing cities, one that can only be overcome through more effective governance.

The ongoing under-resourcing of municipal authorities compounds these issues. Transfers from central government can be unreliable or insufficient: in Kampala, transfers from central government often fall below predictions.⁵² Political constraints on revenue raising and spending, and corruption and governance failures are entrenched. In both Kampala and Jinja, the specific tax through which the city government raises revenue for street lighting is equivalent to 2 billion UGX per year (~540,000 USD) that is currently being collected at around 60 percent efficiency. Regulations dictate that this money can only be spent in the areas from which it was raised⁵³ – effectively making informal settlements ineligible. In general, revenue collection is inefficient and concentrated in pockets of economic activity, meaning that investment is prioritised in these areas. Investments in lighting must compete with other vital public services for limited revenues, such as managing transport and waste, and different parts of cities are prioritised over others, leading to a patchwork service provision.

A final challenge is the complexity of introducing street lights where there are no formal streets. This could be linked to issues surrounding gentrification. In Kibugumbata, the value and desirability of land has increased, and new housing developments are already underway. Locals expressed concern that land titles would not be granted to the residents of the informal settlement but that instead they could be evicted and the land sold to developers. When investing in infrastructure in areas where inequality is high and land tenure is contested, there is a considerable risk that disempowered communities may benefit from services in the short term but lose out in the long term. It is therefore imperative that any efforts to provide essential public services – including street lights – are integrated into strategies to address the root causes of poor service provision: exclusion, marginalisation and inequality.

Scaling up the benefits

Based on experience from Kampala and Jinja, the benefits of rolling out solar street lighting could be significant not only in Uganda but also in countries across sub-Saharan Africa. For example, for every 1,000 km of new road that is installed with solar-powered street lights in place of conventional ones, installation costs will be reduced by approximately 80 billion UGX (~21 million USD), electricity consumption will be reduced by 40 percent and maintenance costs will be reduced by 60 percent. The World Bank estimates that between 60,000 and 100,000 km of new roads are needed to provide intra-continental connectivity in Africa.⁵⁴ Lighting these roads with solar would be an opportunity to substitute the consumption of grid-based electricity with the generation and consumption of between 96 and 160 GW of distributed renewable energy (equivalent to more than doubling energy generation in sub-Saharan Africa, currently at just 92 GW).⁵⁵

In Jinja, solar street lighting could pay for itself through the money saved on electricity bills and generated from advertising space on poles, with the extra street lighting stimulating economic activity in more parts of the city. In Kampala, this could be particularly significant. Prior to a ban on street vending in the capital city in 2011, there were approximately 8,500 informal entrepreneurs working across the city.⁵⁶ Formalising these activities by designating spaces for trade and adding street lights could have added an extra 42,500 hours of economic activity per day, equivalent to almost 4,000 more full time jobs in the city. Extended across Uganda's urban areas, similar measures could create more than 14,000 full time jobs, and across East Africa this could amount to more than 160,000 jobs.⁵⁷ Strengthening the night-time economy in cities by providing safe spaces for workers and street lighting could therefore provide substantial benefits to national governments by stimulating inclusive national economic growth.

Solar-powered street lighting could also be adopted by other urban centres across Uganda as a partial solution to the high electricity costs and low revenue collection that has hampered local governments and the country's decentralisation agenda. According to the National Roads Authority, there are 2,800 km of urban roads in Uganda. If these were fitted with conventional street lights, the initial cost would be 896 billion UGX (~238 million USD) and the already unaffordable electricity costs would increase. If they were fitted with solar street lights, then the initial cost would be 672 billion UGX (~178 million USD). If the solar street lights were partly fabricated locally – as has happened in Kibugumbata – the cost would drop to 448 billion UGX (~119 million USD).

Ensuring local communities benefit from the job creation and market stimulus that accompany investment in the solar sector can unlock multiple benefits in informal settlements. For residents, it can be a means by which to access legal land tenure, while the enhanced feeling of citizenship fostered by inclusion can lead them to make a greater contribution to municipal duties, including by paying taxes.⁵⁸ Having organised communities – like those in Kibugumbata who benefitted from the Municipal Development Forums established under the TSUPU programme – can help to ensure that service provision is demand-driven and aids the intended beneficiaries. This can also create space for ongoing dialogue between municipal authorities and the urban poor. Here, the involvement of NGOs is also critical, as experience in other cities in Africa and worldwide shows; NGOs engage in a range of activities to ensure green jobs and livelihoods are sustainable when there is a lack of continued support from formal institutions and markets.^{59,60} An awareness of the embedded inequalities and power dynamics within the informal economy and local contexts is essential when seeking to upscale such technologies. For instance, connecting the solar lighting infrastructure to charging stations could provide electrification for street vendors that would enhance their activity; however, it is worth noting that there are examples of such infrastructure being resisted by the vested interests of existing providers (such as local businesses and middlemen), being misused by vendors or being poorly maintained.⁶¹

In terms of avoided electricity costs, replacing all of Kampala's existing conventional lights with solar ones would reduce the city's monthly electricity bill by around 31.2 million UGX (~8,293 USD).^a The overall business case for

a Roughly 8 percent of KCCA's electricity costs are due to street lights and government owned buildings

choosing solar over conventional street lights could be affected by a reduction in the electricity tariff paid by local governments, but this would only have a marginal impact. The overall maintenance costs make up the bulk of the price difference, and these are not affected by tariff changes. Uganda already has excess electricity capacity on the national grid due to its strong, and growing, hydroelectric sources. Despite this, local governments remain on relatively expensive tariffs and, in the cases of Kampala and Jinja, are stuck with a utility provider that has a monopoly on the market.

Box 2

Economic potential of switching to solar street lighting nationwide

- It would be at least 224 billion UGX (~60 million USD) cheaper to install solar street lights rather than conventional ones in urban areas in Uganda.
- Replacing existing street lights would result in a 40% reduction in electricity consumption and a 60% reduction in maintenance costs.
- 14,000 more jobs could be created nationwide thanks to extended trading hours.

If national governments put in place the policy framework needed to roll out solar-powered street lighting across urban areas that are currently without street lighting nationwide, they could realise multiple co-benefits for society, the economy and the environment. Solar street lights could generate economic benefits such as the growth of domestic solar technology markets and job creation; social benefits such as reduced crime, improved road safety and greater social inclusivity; and climate-related benefits associated with renewable energy generation.

Policy recommendations

Five main policy recommendations emerge from this study:

1. Adopt solar-powered street lighting as the norm in urban areas

The significant fiscal and environmental benefits of solar-powered street lighting suggest it should be prioritised over grid-based street lighting in urban planning henceforth. Both public and private developments should incorporate provisions for solar street lights – planning approval could be dependent on this. Mandating that new urban development should include solar-powered street lighting would help to grow local markets for solar power while generating social and environmental benefits. For instance, all new road developments and resurfacing nationwide could include solar street lights. Large public or private developments could be required to fund the installation of solar street lights on surrounding public streets or within the private perimeter, and an operation and maintenance period could be specified in the initial contract with the supplier or developer. City development plans and infrastructure spending should consider the wider benefits of installing solar street lights in poorer parts of the city and on roads connecting them.

2. Introduce national regulations on solar technology and provide guidelines and support for the sector and for local commissioners

To avoid technology dumping and costly inefficiencies, better regulation of solar technology (whether being imported and manufactured locally) needs to be introduced. National governments should adopt and adhere to recognised standards and certifications for solar-powered lighting equipment to ensure the best available technologies are adopted, within financial limits. Any financial incentives provided by government – such as duty and tax

reductions on imports – should only be given to products complying with the standards in order to reduce their prices. This should be complemented by technical support from the state in tender development and purchasing for local authorities or other actors seeking to buy or invest in solar projects. This will help to create a competitive domestic market in off-grid solar. Opportunities for knowledge and technology transfer also need to be taken more actively, with national government facilitating engagement with other frontrunner cities and countries as well as transnational networks to ensure access to the most up-to-date information and technology.

3. Work with the private sector to facilitate uptake of solar street lights

Local businesses should be supported and encouraged to install solar lights on the streets around their premises. Bringing new or improved lighting to business districts is a common interest for municipal authorities and businesses, so co-financing arrangements could be developed to facilitate this. Furthermore, opportunities for engaging solar providers should be explored. To incentivise this, national governments could consider power purchase agreements for any additional power generated, or could offer favourable tariffs. These measures could be complemented with government-backed schemes aimed at developing the skills base of local manufacturers and technicians, such as apprenticeships and subsidies, which would help generate jobs locally and help grow the market.

4. Empower local communities to be involved in urban planning and to co-produce lighting for public spaces

Meaningful engagement with local communities can empower the households that live in otherwise marginalised areas of the city, allowing them to hold governments to account and enable them to feel like citizens who are more likely to contribute directly to city life. Co-production should be demand driven, so national governments could support enumeration and mapping activities to identify priority areas for lighting. Organised communities can also be involved in financing such developments, through savings groups or service-specific levies in informal settlements where other city authorities are not currently investing. Furthermore, municipal expenditure options could be reformed to allow redistribution towards lower-income parts of the city, for example by removing restrictions on specific taxes. Actions such as these would allow national governments to create a policy environment which encourages city authorities to collaborate with local communities.

5. Improve the management and accountability of municipal budgets to ensure public services are adequately funded and sustainable

Better budgeting for operation, maintenance and other unforeseen costs needs to take place to avoid increased future costs due to technology failures. National governments can provide training for finance and accounting staff in municipalities. They can help also strengthen the capabilities of municipal governments by guaranteeing reliable and adequate fiscal transfers, and by establishing clear legislation, guidelines and processes for municipalities to follow regarding the collection of own-source revenues. National project preparation facilities could be established to provide financial and technical assistance, including support for budgeting and planning maintenance costs. This could enable the public sector to lower the costs of project development and financing. This recommendation is not just relevant for solar street lights but relates to a broader fiscal agenda of financing urban sustainable infrastructure.⁶²

Conclusions

Unplanned urbanisation, entrenched poverty and poor municipal finances are all putting pressure on the provision of basic public services in developing country cities. There are opportunities for avoiding conventional high-carbon and high-cost forms of infrastructure if central governments can support municipal authorities in adopting technologies that better suit their local development and finance contexts, and that can empower them to budget more effectively by building infrastructure that they can sustain in the long term.

Electricity costs are a large part of municipal budgets, so the adoption of alternative, efficient off-grid technologies could help reduce this burden. Solar-powered street lighting is an example of such a technology that can have social and environmental benefits as well as economic advantages. The benefits of choosing solar-powered street lights over conventional grid-connected ones are numerous. They are cheaper in terms of capital, operational and maintenance costs – meaning that more street lights can be installed for the same cost. Street lighting also provides socio-economic benefits, including improving safety and lengthening trading hours for street vendors, as well as the environmental benefits associated with renewable energy generation.

This brief has highlighted examples from Uganda. In Kampala, the installation of 1,800 solar street lights on city roads has already saved the Kampala Capital City Authority around 4 billion UGX (1 million USD) in installation costs compared to conventional street lighting, as well as removing electricity costs. Replicating this model across sub-Saharan Africa could be 21 million USD cheaper than conventional street lighting, reduce public electricity consumption by 40 percent, and bring about reductions in maintenance costs of up to 60 percent for every 1,000km of road where solar street lights are installed in place of conventional ones.

An example from the informal settlement of Kibugumbata in Jinja highlights how the benefits of solar street lighting can be further strengthened by sharing the responsibilities of implementation with local communities, NGOs, and municipal authorities. The co-production of this basic service has helped to strengthen existing livelihoods by allowing trading to continue outside of daylight hours, enhanced safety and security in the area, and created jobs in the solar sector for vulnerable populations. In addition, it has created a space for engagement between the municipal government and low-income residents, who might otherwise have remained excluded from processes of urban planning. Such models can transform relations between the urban poor and the state, contributing to more sustainable and inclusive urban development.

To upscale these benefits, national governments need to develop a robust regulatory framework to grow and control domestic solar markets. More generally, they could help municipal governments to improve their budgeting, both by providing adequate and reliable central transfers and by helping to develop revenue at the city level. This would contribute to a broader fiscal agenda of financing urban sustainable infrastructure. Most importantly, national governments should ensure that municipal authorities collaborate with local communities and other actors to jointly design and implement green infrastructure and basic services such as solar-powered street lighting. Doing so could realise multiple co-benefits for society, the economy and the environment.

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ABOUT THE COALITION FOR URBAN TRANSITIONS

The Coalition for Urban Transitions – launched in 2016 at the Climate Leaders’ Summit in New York – is a major new international initiative to support decision makers to unlock the power of cities for enhanced national economic, social, and environmental performance, including reducing the risk of climate change. The Coalition provides an independent, evidence based approach for thinking about ‘well managed’ urban transitions to ensure that the growth of urban areas, and the accompanying process of economic, social, and environmental transformation, maximises benefits for people and the planet.

The initiative is jointly managed by the **C40 Cities Climate Leadership Group (C40)** and **World Resources Institute (WRI) Ross Center for Sustainable Cities**.

Members include over 20 major institutions spanning five continents, including research institutions, city networks, international organizations, infrastructure providers, and strategic advisory companies. The initiative will be overseen by a Global Urban Leadership Group to steer and champion the work.

Follow the Coalition’s work at www.coalitionforurbantransitions.org on LinkedIn, on Twitter @NCEcities and Facebook @coalitionforurbantransitions.

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